OBSERVATION ON THE REPRODUCTION OF *LEUCISCUS CEPHALUS ORIENTALIS* (CYPRINIDAE) IN SAVUR STREAM (TURKEY)

by

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ABSTRACT. - The reproduction of a population of *Leuciscus cephalus orientalis* in Savur Stream, a branch of the Tigris River in the south-eastern Anatolia was studied. This subspecies has a spawning period extending from May to late June. Male and female become sexually mature at the second and third year of their life-span, respectively. The number of eggs were ranged from 2050 to 20140. Fecundity (F) was significantly correlated with fish length (FL), fish weight (W), and gonad weight (GW). Fecundity increased at a rate less than that of body weight and gonad weight, in relation to length.

RÉSUMÉ. - La reproduction de la population de *Leuciscus cephalus orientalis* a été étudiée dans le Savur, un affluent de la rivière Tigre au sud-est de l'Anatolie. Cette espèce se reproduit de mai à fin juin. La maturité sexuelle est atteinte respectivement chez les mâles et les femelles à la deuxième et troisième année de leur vie. Le nombre d'oeufs dans les ovaires est compris entre 2050 et 20140. La fécondité (F) est significativement corrélée avec la longueur du poisson (FL) le poids du poisson (W), et le poids des gonades (GW). Par rapport à la longueur des individus, la fécondité augmente dans des proportions moindres que les poids du corps et des gonades.

Key-words. - Cyprinidae, *Leuciscus cephalus orientalis*, Savur Stream, Turkey, Reproduction.

Leuciscus cephalus orientalis (Nordman, 1840) is one of the most common and widely distributed Cyprinid subspecies in south-eastern Anatolia (Kuru, 1979). It is furthermore a subspecies subjected to fishing, especially in rivers, streams and reservoirs.

In the literature, there is some information concerning the growth and reproduction of the chub, *Leuciscus cephalus* inhabiting some European and Turkish freshwaters (Lelek, 1959; Holcik, 1967; Hellawell, 1971; Geldiay and Balik, 1973; Mann, 1976; Penaz *et al.*, 1978; Libosvarsky, 1979; Poncin *et al.*, 1987; Neophitou, 1988; Öztas, 1989), but few studies on *Leuciscus cephalus orientalis* (Sen, 1988: Ünlü *et al.*, 1990).

The present study was therefore undertaken, in order to investigate the reproduction of the *Leuciscus cephalus orientalis* population in Savur Stream, a branch of the Tigris River, in the south-eastern Anatolian region of Turkey.

MATERIALS AND METHODS

The study was carried out on the *Leuciscus cephalus orientalis* population in Savur Stream, which is a branch of the Tigris River in the south-eastern region of Anatolia (Fig. 1). 492 specimens (322 females and 170 males) were captured in sites where the water flow is very slow, during the period from December 1988 to November 1989. The sampling was made by gill-nets of various mesh-sizes (18x18, 24x24, 30x30

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Cybium 1993, 17(3): 241-250.

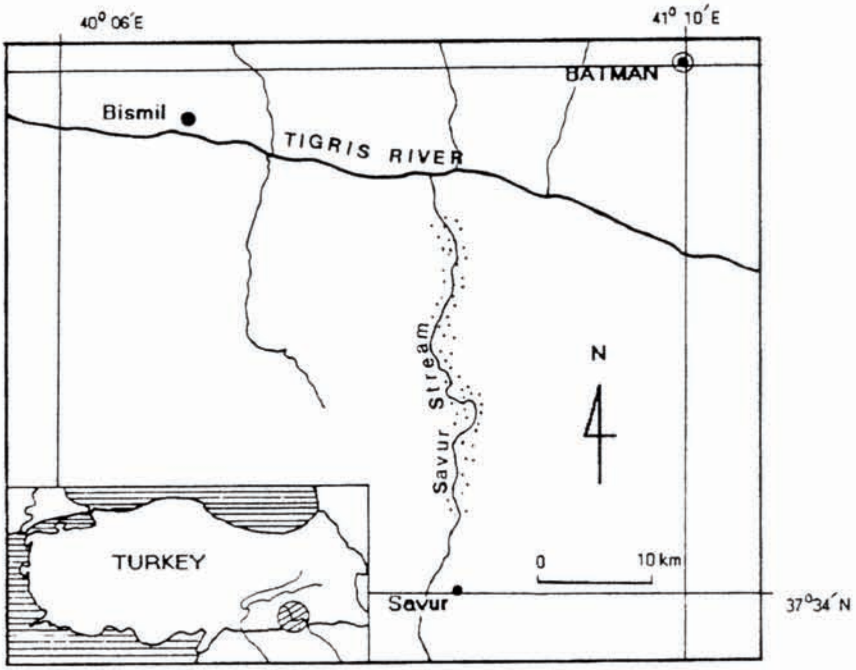

Fig. 1. - Map of Savur Stream, sample site of *Leuciscus cephalus orientalis*.

mm) and electrofishing with power supplied by a Honda AC/DC generator delivering 240 V at 1.5 A. After being caught, fish samples were brought to the laboratory; the fork length and weight were measured to the nearest 1.0 mm and 0.1 g respectively. Scales were used for age determination; for this purpose, six to ten scales were taken from the middle region of the side of the body and read under a binocular microscope. The sex was determined by examination of the gonad tissue either by eye in bigger specimens or with the aid of a stereomicroscope in smaller. The gonads were removed and weighed to the nearest 0.01 g. The monthly gonado-somatic index (GSI) was calculated as follows:

$$GSI = \frac{\text{Gonad weight}}{\text{Body weight - Gonad weight}} x\, 100$$

The number of eggs (absolute fecundity) was estimated by a gravimetric method using pairs of the ovaries of stage V that preserved in 4% formalin solution according to the method suggested by Libosvarsky (1979). The diameters of ripening ova were also measured. About fifty ova selected at random from each ovary were measured by means of a micrometer eye-piece and the mean egg diameter was then computed for the entire samples. Data obtained involved about 500-600 eggs per month. The relationship between body weight (W) and gonad weight was calculated with linear regression analysis. On the other hand, fecundity (F)-fork length (FL), fecundity-body weight (W) and fecundity-gonad weight (GW) regressions analyses were calculated by means of the least squares method on logarithmic transformed data (Pantulu, 1963: Pitcher and Mac Donald, 1973):

$$\log F = \log a + b \log FL, \qquad \log F = \log a + b \log W,$$
$$\log F = \log a + b \log GW$$

RESULTS

Spawning

Assessment of the timing of the main spawning season of *Leuciscus cephalus orientalis* in Savur Stream was based on the gonado-somatic index (GSI) (Fig. 2), analysis of seasonal development in mean egg diameter, and direct observation of the gonads (Table I). There were marked individual variations in the pattern of monthly GSI values, as shown by the vertical columns that represent the maximum and minimum values of 322 females (Fig. 2). According to these averages, the highest GSI values were determined in the May samples. There was a decrease in the mean GSI values of June, when spawning took place in almost all individuals. Since a few individuals caught in

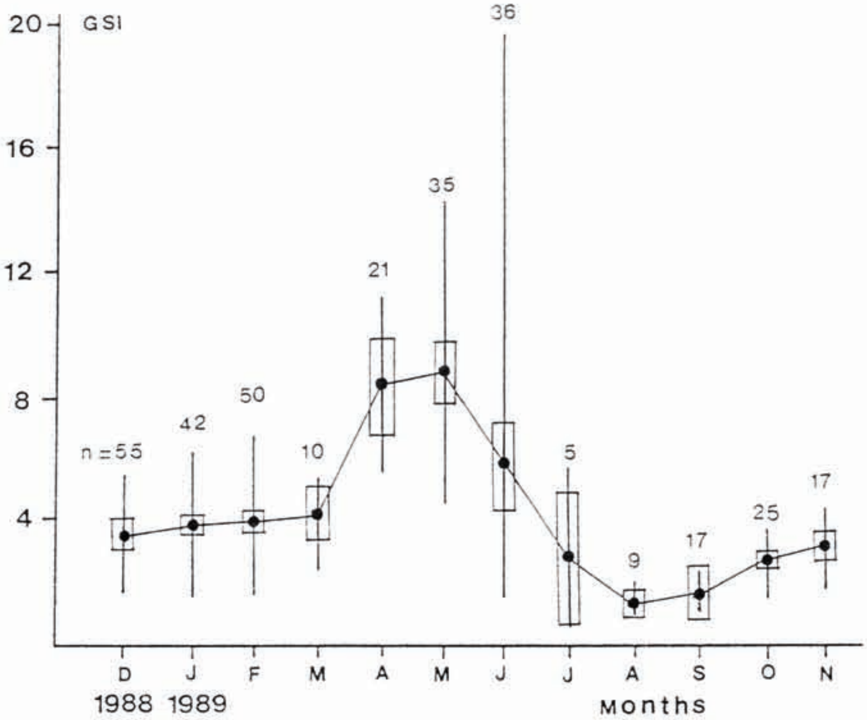

Fig. 2. - Monthly variations in the gonado-somatic index (GSI) values of female *L. cephalus orientalis* during a 12-month-period in Savur Stream (means indicated by dots, ranges by vertical bars, boxes indicate 95% confidence intervals of the means).

Table I. - The percentage of spent and unspent in females of *L. cephalus orientalis* captured in the period April-July in Savur Stream.

Date	No. fish	Unspent (%)	Spent (%)
30 April 1989	6	100.00	-
08 May 1989	16	81.75	18.75
21 May 1989	19	78.94	21.06
03 June 1989	25	52.00	48.00
24 June 1989	11	27.73	72.27
08 July 1989	5	-	100.00

July retained a few eggs in their ovaries, the mean GSI value was higher in the July samples when compared with August.

We observed oocytes in ovaries at all seasons. The mean egg diameter was highest in May, while the smallest was measured in August when the ovaries contain only oocytes which will develop the following year (Fig. 3). There is a gradual increase

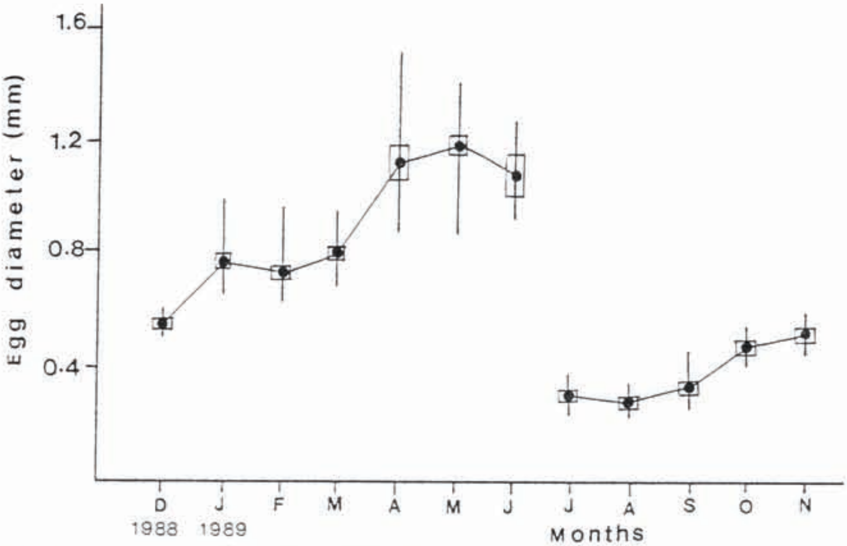

Fig. 3. - Monthly variations in egg diameter of *L. cephalus orientalis* in Savur Stream (means indicated by dots, ranges by vertical bars, boxes indicate 95% confidence intervals of the means).

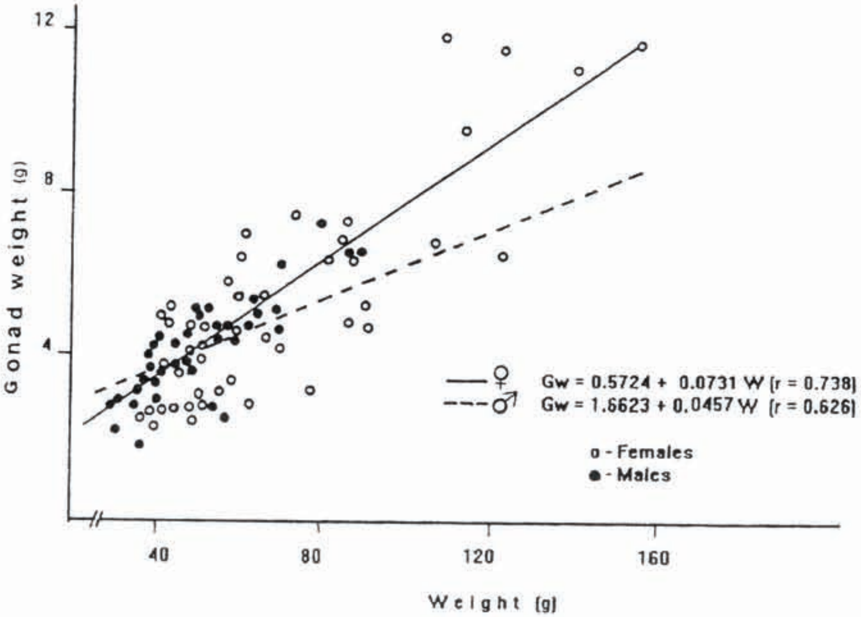

Fig. 4. - Relationship between fish weight (W) and gonad weight (GW) of *L. cephalus orientalis* population in Savur Stream. The lines were computed from the regressions.

in egg diameter from September onwards until the new spawning season. We found low correlation between egg diameter and fish weight in samples of stage V ($r = 0.203$).

According to the GSI values, seasonal increase in ova size, and direct observation of the gonad, the beginning of spawning took place in May and continued until late June in this *Leuciscus cephalus orientalis* population (Table I).

The relationship between the gonad weight (GW) and fish weight (W) of 44 females and 37 males was calculated by linear regression. Data from mature males and females were treated separately and gave the following equations:

Males, $GW = 1.6623 + 0.0457\ W \quad (r = 0.626)$

Females, $GW = 0.5724 + 0.0731\ W \quad (r = 0.783)$

When plotting gonad weight against fish weight, the scatters show a positive correlation between these variables (Fig. 4). The relation may be regarded as linear. It has been estimated that, correlation between ovary weight and fish weight was higher than correlation between testis weight and fish weight. This may indicate that ovary weight increases in a greater degree than testis weight.

Age at sexual maturity

The age of attaining sexual maturity was traced on actual observation of 121 females and 53 males captured in the spring period (March-May) (Table II).

Table II. - Numbers of immature and developing individuals in age groups I-VII of *L. cephalus orientalis* in Savur Stream.

	Age groups	I	II	III	IV	V	VI	VII	No. fish
Females	**Immature**	5	4	7	2	-	-	-	121
	Developing	-	-	28	52	18	2	3	
Males	**Immature**	2	2	-	-	-	-	-	53
	Developing	-	6	25	14	4	-	-	

The females at first and second years and males at first year had not yet attained sexual maturity. On the other hand, 80% of females and 75% of males attained sexual maturity at their third, and second, year respectively. The mean length (FL) and weight (W) were calculated separately for both sexes, mature and immature (Table III). There were small differences between mature and immature individuals of both sexes in their length and weight at the same age, but according to the results of student-t test, the difference was not statistically significant ($P < 0.05$).

Fecundity

Fecundity was estimated in 42 females captured just prior to spawning; GSI ranged between 4.44 and 14.4. The number of eggs were ranged from 2050 to 20140. There were significant correlations between fish length (FL), fish weight (W), and gonad weight (GW) versus fecundity (F) ($P > 0.05$). These relationships were:

$\log F = -1.3391 + 2.3680 \log FL \quad (r = 0.745)$

$\log F = 2.4329 + 0.7912 \log W \quad (r = 0.761)$

$\log F = 3.2762 + 0.8163 \log GW \quad (r = 0.775)$

The correlation coefficient of fecundity with gonad weight is similar to those of fecundity with fish weight and length. That means there is a clear trend of increasing egg numbers with fish length, weight and gonad weight. The relationship between fecundity and fish length may be regarded as slightly concave, while the relationships between fecundity and fish weight and gonad weight are slightly convex (Fig. 5). It appears that,

Table III. - Mean length and weight in age groups I-VII of males and females of *L. cephalus orientalis* from Savur Stream.

Age	N		Mean length (mm)			
			Female		Male	
	F	M	Immature	Mature	Immature	Mature
I	5	2	78.17 ± 20.54	-	88.11 ± 4.25	-
II	4	8	127.34 ± 4.95	-	126.00 ± 2.83	130.25 ± 5.32
III	35	25	137.90 ± 9.29	146.33 ± 12.37	-	142.78 ± 7.93
IV	54	14	154.00 ± 8.48	164.82 ± 19.32	-	153.82 ± 14.30
V	18	4	-	181.77 ± 15.24	-	176.33 ± 24.91
VI	2	-	-	190.60 ± 23.06	-	-
VII	3	-	-	196.00 ± 5.63	-	-

Age	N		Mean weight (g)			
			Female		Male	
	F	M	Immature	Mature	Immature	Mature
I	5	2	14.82 ± 5.60	-	16.50 ± 2.12	-
II	4	8	38.43 ± 6.39	-	36.50 ± 4.95	37.50 ± 3.11
III	35	25	44.30 ± 10.62	50.60 ± 13.63	-	46.69 ± 7.64
IV	54	14	47.50 ± 21.92	75.57 ± 29.27	-	59.27 ± 17.26
V	18	4	-	100.46 ± 27.23	-	80.67 ± 31.90
VI	2	-	-	110.60 ± 50.21	-	-
VII	3	-	-	185.11 ± 10.93	-	-

fecundity increases at a rate less than that of body weight and gonad weight, in relation to length. On the other hand, a minor correlation was estimated between fecundity and fish age (r = 0.563), while correlation between fecundity and egg diameter was not significant (r = 0.256).

DISCUSSION

In this study, according to the gonado-somatic index (GSI) values, the investigation of ova size and direct observation of gonads of *Leuciscus cephalus orientalis* population in Savur Stream, revealed that spawning of this subspecies took place in May and June. Sen (1988), in his work on the *L. cephalus orientalis* population in Kalecik reservoir (Turkey), showed that the subspecies there has an extended spawning season from April to August. The gonado-somatic index values were highest in May, and decreased in July, for both Savur and Kalecik populations (Turkey). That means that almost all individuals of both populations spawned in the May-June period; very few individuals from Sen's (1988) collection were still unspawned in July and August. Similar results have been reported for other *L. cephalus* populations in some European and Turkish freshwaters. Hellawell (1971), in his work on *L. cephalus* population from the Afon Llynfi River (Great Britain), deduced a maximum gonadal weight in May, and minimum in July; all females in the population were spent in June. Poncin *et al.*, (1987)

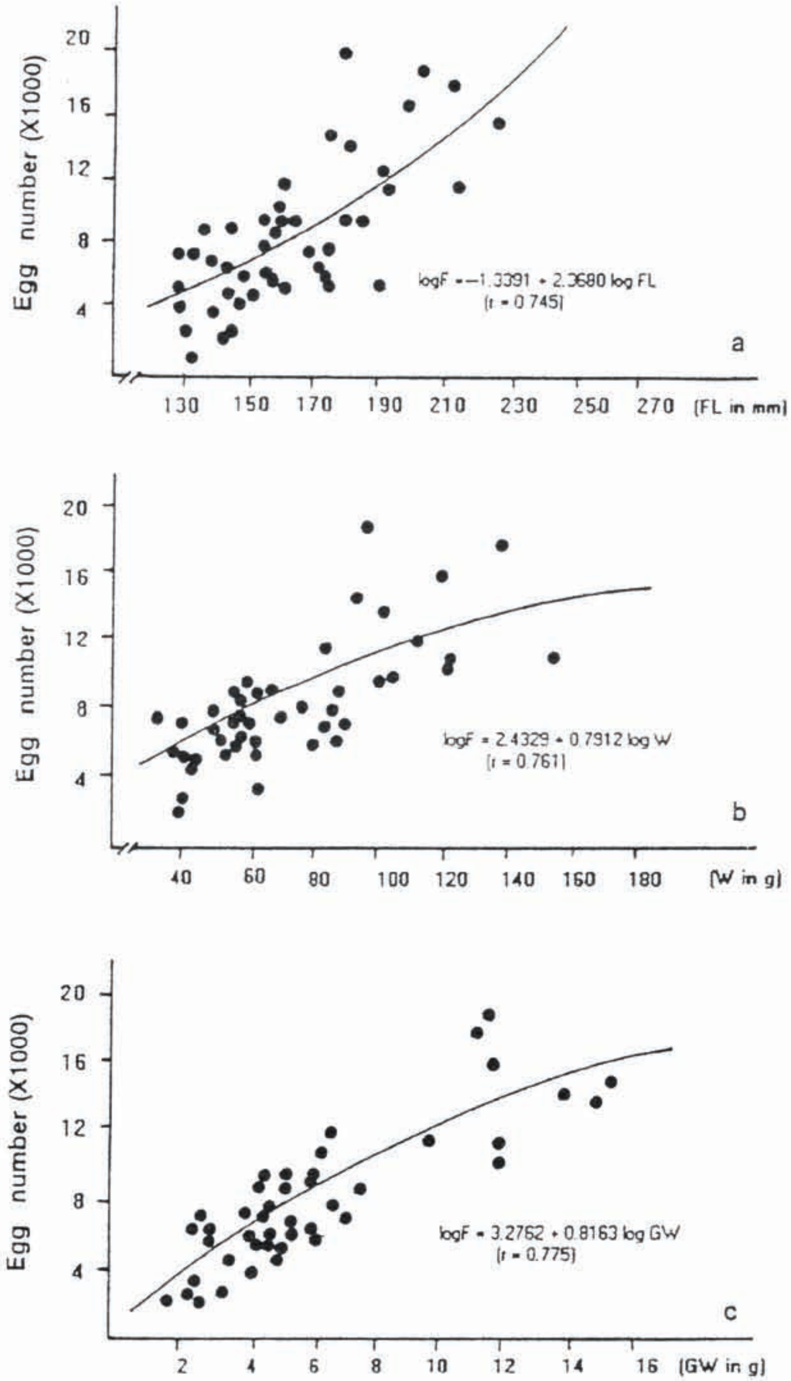

Fig. 5. - Relationships between fecundity and fish length (a), fish weight (b) and gonad weight (c) of *L. cephalus orientalis* in Savur Stream. The curves were computed from the regressions.

determined that spawning in the *L. cephalus* occurred in the May-June period in heated water and under a natural or controlled photoperiod. Neophitou (1988) recognized that spawning of the *L. cephalus* population in the Rentina River (Greece) occurred at the end of April and beginning of May; also Öztas (1989) reported that in the Müceldi Stream (Turkey) the spawning period of the *L. cephalus* population occurred at the end of May and in June. Although, Holcik (1967) mentioned a partial spawning in females of the Klicova reservoir (Czechoslovakia) population there was no evidence for this in the *L. cephalus orientalis* population in Savur Stream. On the other hand, Penaz *et al.*, (1978) showed that spawning of *L. cephalus* took place in May and June, but some individuals retained eggs in their ovaries and the ovaries showed signs of egg resorption. As has been mentioned by a number of investigators, the spawning cycle is closely related to temperature. These results show that spawning of both *L. cephalus* and *L. cephalus orientalis* occur at almost the same time, which is the end of spring and beginning of summer as the temperature rises. A slight variation between different populations may be seen because of different ecological conditions.

In this study, it has been found that there was low correlation between egg diameter and fish weight ($r = 0.203$). The egg size is probably related to the amount of food that females can metabolize, assimilate and store in each egg (Neophitou, 1988). According to Hellawell (1971), the mean egg diameter in the Lugg and Afon Llynfi (Great Britain) *L. cephalus* populations ranged between 1.25 and 1.95 mm. But Libosvarsky (1979) stated that the mean egg diameter of the *L. cephalus* population in the Rokytna River (Czechoslovakia) ranged between 0.96 and 1.35 mm. Öztas (1989) showed that the mean egg diameter ranged from 0.55 to 1.35 mm in the Müceldi Stream population (Turkey), while in the *L. cephalus orientalis* population in Savur Stream egg diameter ranged between 0.83 and 1.50 mm.

Male and female *L. cephalus orientalis* become sexually mature in their second and third year of life when they have reached a fork length of about 130 mm and 146 mm, respectively, in the Savur Stream population, while in the Kalecik reservoir (Turkey) they attain sexual maturity in their third year (Sen, 1988). Ages at sexual maturity are almost similar in other cyprinid fish, such as roach and barbel species (Libosvarsky *et al.*, 1984; Lobon-Cervia and Fernandez-Delgado, 1984; Silva *et al.*, 1985; Neophitou, 1987). In this study, no significant differences were found between the mean length and weight for both males and females of the same age groups ($P < 0.05$). The ages of sexual maturity in *L. cephalus* populations from the other waters are given in Table IV. The comparisons revealed that sexual maturity occurs in the second and third years in most *L. cephalus orientalis* and *L. cephalus* populations, but the Afon Lynfi River and Müceldi stream samples were older at maturity (Hellawell, 1971; Öztas 1989). The average age of maturation is directly related to the population density and ecological conditions, particularly temperature (Nikolsky, 1963). For example, during May and June the temperature of the water in the Savur Stream ranged from 15°C to 23°C, while in the Müceldi Stream, it ranged between 12-18°. Although, there is no temperature data for the

Table IV. - Age at sexual maturity in different *L. cephalus* and *L. cephalus orientalis* populations.

Leuciscus cephalus orientalis				***Leuciscus cephalus***			
	Savur stream	Kalecik reservoir Sen, 1988	Müceldi stream Oztas, 1989	Pinarbasi stream Geldiay & Balik, 1973	Rokytna river Lelek, 1959	Afon Llynfi river Hellawell, 1971	Rentina stream Neophitou, 1988
Male	2+	3+	4+	2+	2+	7+	2+
Males	3+	3+	4-5+	3+	3+	7-8+	2+

Afon Lynfi River, may be it has a low temperature since Hellawell (1971) reported that this river was chosen as representative of salmon-spawning areas.

There are few published data related to fecundity of *L. cephalus* populations: Hellawell (1971) suggested a range of 10000-20000 eggs based on gonad weights. Libosvarsky (1979) mentioned that, the number of eggs ranged between 4470 and 29780, Öztas (1989) gave 1960-61808 eggs, while the number of eggs of *L. cephalus orientalis* in the Savur Stream ranged between 2500 and 20140. From the above mentioned survey, it can be stated that our *L. cephalus orientalis* population has a low reproductive cost, compared with the other *L. cephalus* populations. This may be due to differences of subspecies, genetics and ecological factors such as food supply, population density and changes in temperature. As mentioned earlier, temperature is an important ecological factor affecting egg numbers in a *Cyprinion macrostomus* population (Bardakçi and Tanyolaç, 1990). A positive correlation between fecundity and fish weight and length has been described in most freshwater fish populations. In a *L. cephalus orientalis* population, however, fecundity increases at a rate less than that of body weight and gonad weight, in relation to length. The correlation coefficient of fecundity with fish weight is similar to fecundity with gonad weight. Similar relationships between fecundity and length, fish and gonad weight were stated previously in *Osteogeneiosus militaris* (Pantulu, 1963) and *Barbus barbus bocagei* (Lobon-Cervia and Fernandez-Delgado, 1984).

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Reçu le 14.05.1992.
Accepté pour publication le 22.02.1993.